UTILIZATION OF WASTE

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SYNTHESIS OF DECORATIVE GLASS-CERAMIC MATERIAL BASED ON TINTED SLAG

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A decorative glass-ceramic material was synthesized on the basis of tinted waste (slag). The resulting material has high chemical and thermal resistance, a saturated blue color, and can be used in various sectors of industry.

The process of tinting is used in the production of various decorative glasses and glass ceramics to obtain a decorative effect. As a rule, pure raw materials or cullet are used for this purpose. The development of compositions for decorative glasses and glass ceramics including industrial waste is of particular interest, as it solves a number of environmental and economic problems.

The South Russian State Technical University carried out research with a view to producing decorative materials based on slag waste generated by the metallurgical industry, which has a saturated blue color. The composition of the tinted waste is as follows (here and elsewhere wt. %): 26.00 SiO_2, 45.88 Al_2O_3, 1.98 CaO, 3.82 MgO, 7.64 NiO, 7.65 Fe_2O_3, 4.28 CuO, 0.78 Mn_2O_3, 1.57 Cr_2O_3, 0.15 TiO_2, 0.15 Na_2O, 0.07 Mo_2O_3, 0.01 Ag_2O, 0.01 InO, and 0.01 Nb_2O_3. The color of this slag resembles natural lazurite that has the following chemical composition (%): 37.89 SiO_2, 39.88 Al_2O_3, 9.97 Fe_2O_3, 4.98 CaO, 3.99 MgO, 0.29 NiO, 0.99 CuO, 1.99 Na_2O, 0.01 MnO, and 0.01 (Ag_2O + PbO + PdO).

The waste slag was investigated using spectral, chemical, and x-ray phase analysis.

The spectral analysis was implemented on a PZhS-2 spectrograph in the arc and spark modes with a strength of current 10 – 20 A. The lines were interpreted using a MD-2 microanalyzer. The elemental composition of the slag waste was identified: Na, Cu, Ag, Mg, Ca, Zn, Al, In, Si, Ti, Nb, Cr, Mo, and Mn.

The x-ray phase analysis was performed on a DRON-2 set with copper K_x radiation. The possible phase composition of the slag was investigated using the electron database HCDD PDF Philadelphia (1995) listing more than 57,000 compounds.

The temperature of the metallurgical process generating this tinted waste is 2500 – 3000°C. It is found that the main phase of the slag waste is a spinel of the form (Cr, Ni, Mg, Fe, 2/3 Al) Al_2O_4 (up to 70 – 80%) with inclusions (up to 30%) of metals and SiO_2.

The slag waste is only partly (5%) dissolved in hydrochloric, sulfuric, nitric, and chloric acids and their mixtures, even when heated to 100°C, and dissolves to an extent of 18% in hydrofluoric acid at a temperature of 900°C.

The material mixture components were selected in such a way as to ensure a low temperature of synthesis of the decorative glass-ceramic material, i.e., 1000 – 1100°C. To lower the temperature of synthesis, along with the slag waste we used borax $Na_2B_4O_7 \cdot 10H_2O$, soda Na_2CO_3, and soluble glass. The material mixtures contained (%): 40 – 70 slag, 8 – 16 borax, 18 – 24 soda, and 10 – 20 soluble glass.

After heat treatment of the prepared mixtures in an electric furnace with silit heaters (temperatures 1000 – 1100°C, duration 1 – 3 h) a decorative glass-ceramic material of a saturated blue color was obtained.

The degree of crystallinity of the material was estimated using an optical microscope and x-ray phase analysis. The density of slag and slag-based glass ceramic were measured by the pycnometry method. Before that the slag and the slag-based material were milled until they pass through a No. 006 sieve (10,000 holes/cm^2). The heat-resistant tests were performed as follows: the materials obtained were heated up to 600°C, then exposed for 20 min and cooled in air. The state of the materials after testing was evaluated using an optical microscope. The thermal resistance of the synthesized materials was estimated based on the number of thermal cycles of 600 – 20°C. The color of the material was determined visually.

It was found that the temperature of synthesis of the material is 1000 – 1100°C, its density 3500 kg/m^3. The material obtained has high chemical and thermal resistance and can be used both in the production of construction materials and in other sectors, such as architecture, manufacture of jewelry, etc.

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